List of topics to be covered

- Introduction to Theory of Computation
  - What is it all about? Some key problems/questions?
  - What can we compute with computers?
  - Are there things that we cannot compute?
- Math basics
  - Instill a sense of what constitutes a "proof"
  - Set: subsets, union, intersection, complement
  - Sequences and Tuples. Cartesian products
  - Functions as mathematical objects. Relations
- Logic
  - Predicates
  - Boolean operations
  - Implication
  - Laws
  - Proof examples: DeMorgan's rules
- Alphabets
  - Alphabet as a set
  - Strings. Length. Equality. Substrings. Empty string.
  - Lexicographic ordering.
  - Languages. Provide numerous examples.
  - Union, Concatenation, star
- Deterministic Finite Automata
  - Start states, accept states, state diagrams
  - Formal definition
  - Language accepted by an automaton
  - Equivalent automata
  - Example automata: Recognizing integers, identifiers, fractions
  - Regular languages
  - Union of regular languages is regular
  - What about concatenation? What about star?
- Nondeterministic Finite Automata
  - Examples
  - Definition
  - Example NFAs that recognize same language as a DFA
  - An NFA has an equivalent DFA
  - Language regular if and only if a NFA recognizes it
  - Regular languages closed under union

  - Regular languages closed under concatenation
  - Regular languages closed under star
- Regular Expressions
  - Definition
  - Examples
  - Language regular if and only if regular expression describes it ("if" direction optional?)
  - Generalized NFAs?
- Nonregular languages
  - Intuitively: Why must there be nonregular languages
  - Pumping lemma for regular languages
  - Examples
- Context-Free Languages/Grammars
  - Examples
  - Formal Definition
  - What does "context-free" mean?
  - Terminals, productions, variables
  - Derivation in a CFG, Parse Trees
  - Examples of CFGs that are nonregular
  - Ambiguity. What it means programming-wise
  - Chomsky Normal Forms
  - Every CFG has a corresponding CNF
- PushDown Automata
  - Definition
  - Examples
  - State diagrams for PDAs
  - Every CFG has a PDA recongizing it
  - If a PDA recognizes a language, then it is a CFL
- Non-context free languages
  - Pumping Lemma
  - Examples
- Turing Machines
  - Definition
  - Examples?
  - Turing Recognizable vs Turing Decidable languages
  - Multitape and nondeterministic Turing machines
  - The Church-Turing thesis
- Decidability

  - Decidable problems for regular languages, DFAs, NFAs
  - The Halting Problem
  - Diagonalization argument, undecidability of Halting Problem
  - Unrecognizable languages
- Reducibility
  - Reduction of one problem to another
  - Regularity of languages is undecidable
- Optional
  - Optional? Computation Histories
  - Mapping reducibility formally? (Optional?)
  - Computable functions?
  - Recursion Theorem?
  - Minimal descriptions, information theory
- Time Complexity
  - Asymptotic Notation
  - Time Complexity Classes
  - Class P and examples
  - Class NP and examples
  - NP-completeness
  - The P vs NP question
  - Standard NP-complete problems